Summary Report
Particle Transport and Fuelling

by K.J. Mccarthy

on behalf of

G. Motojima, N. Panadero and R. Sakamoto

16th CWGM, 18th to 20th January 2017
Laboratorio Nacional de Fusión, Ciemat, Madrid, Spain

Situation in 2017

Device Operating ≥	LHD ≥1998 ≥2002	TJ-II ≥2014	Heliotron J Late 2016	W7-X (OP1.2) ≥2017	W7-X (OP 2) ≥2019/20
Pellet Rates	Pipe-gun & Extruder (10 Hz)	Pipe-gun: ≤4 pellets ($\Delta t \geq 1$ ms)	Single pellet	Blower gun	Twin Screw Extruder (10 Hz)
H^0 Particles	1 to 2.3×10^{21}	3×10^{18} to 3×10^{19}	$\sim 4 \times 10^{19}$	$\sim 1.8 \times 10^{20}$	$\sim 10^{21}$
Velocity	1400 m/s	650 - 1200 m/s	260+/-30 m/s	250 m/s	600 m/s ?
Inject from	LFS	LFS	LFS	AEK41 (LFS)	?
Diagnostics	Fast camera, $H\alpha$ photodiode matrix, TS, ECE, $\tilde{N}_e$, W_p...	Photodiodes, fast camera, TS, 2 HIBP, μWave, ECE, NPA, W_p, Bolometers, VUV, ...	$H\alpha$ array, TS, FIR, W_p, VUV, ...	TS, ECE, $\tilde{N}_e$, Bolometers, $H\alpha$...?	TS, ECE, $\tilde{N}_e$, Bolometers, ... ?
Modelling (Ablation & Deposition)					

Pellet simulation with HPI2 code
by N Panadero

HPI2 code simulates pellet ablation and material deposition

1) Successfully adapted to **W7-X** by N Panadero (averaged drift along plasmoid parallel length):

- HFS vs LFS
- Injection location effect on particle deposition
- Range of pellet parameters (velocity, size...)

Needs benchmarking

Pellet simulation with HPI2 code by N Panadero

HPI2 code simulates pellet ablation and material deposition

1) Successfully adapted to **W7-X** by N Panadero (averaged drift along plasmoid parallel length):

- HFS vs LFS
- Injection location effect on particle deposition
- Range of pellet parameters (velocity, size...)

Needs benchmarking → **TJ-II** is a possibility

2) **TJ-II**: some outstanding problems remain

→ *e.g.* low T_e, large pellet content to plasma content ratio

→ Simulations for a range of pellet parameters, magnetic configurations, heating regimes, etc. → compare with experiment.

Pellet simulation with HPI2 code
by N Panadero

HPI2 code simulates pellet ablation and material deposition

1) Successfully adapted to **W7-X** by N Panadero (averaged drift along plasmoid parallel length):

- HFS vs LFS
- Injection location effect on particle deposition
- Range of pellet parameters (velocity, size...)

Needs benchmarking → **TJ-II** is a possibility

2) **TJ-II**: some outstanding problems remain

→ *e.g.* low T_e, large pellet content to plasma content ratio

→ Simulations for a range of pellet parameters, magnetic configurations, heating regimes, etc. → compare with experiment.

3) Has been adapted for **LHD** (and **Heliotron J**?)

→Plasmoid drift strongly affected by magnetic configuraion -> needs to be adapted to each device.

→ HPI2 adaption to all device will allow some form of comparison -> how well suited is HPI2 for 3D plasmas?

A. Mischenko looking into pellet ablation and cloud dynamics theory – progress?

Situation in 2017

Device Operating ≥	LHD ≥1998 ≥2002	TJ-II ≥2014	Heliotron J Late 2016	W7-X (OP1.2) ≥2017	W7-X (OP 2) ≥2019/20
Pellet Rates	Pipe-gun & Extruder (10 Hz)	Pipe-gun: ≤4 pellets ($\Delta t \geq 1$ ms)	Single pellet	Blower gun	Twin Screw Extruder (10 Hz)
H^0 Particles	1 to $2.3\text{x}10^{21}$	$3\text{x}10^{18}$ to $3\text{x}10^{19}$	$\sim 4\text{x}10^{19}$	$\sim 1.8\text{x}10^{20}$	$\sim 10^{21}$
Velocity	1400 m/s	650 - 1200 m/s	260+/-30 m/s	250 m/s	600 m/s ?
Inject from	LFS	LFS	LFS	AEK41 (LFS)	?
Diagnostics	Fast camera, Hα photodiode matrix, TS, ECE, $\tilde{N}_e$, W_p...	Photodiodes, fast camera, TS, 2 HIBP, μWave, ECE, NPA, W_p, Bolometers, VUV, ...	Hα array, TS, FIR, W_p, VUV, ...	TS, ECE, $\tilde{N}_e$, Bolometers, Hα...?	TS, ECE, $\tilde{N}_e$, Bolometers, ... ?
Modelling (Ablation & Deposition)	HPI2 ✔ (2012)	HPI2 to be implemented (2017)	HPI2 needs modification	HPI2 ✔ (2016) Benchmarking	HPI2 ✔ (2016) Benchmarking

Proposals

1) **Penetration depth database (IPADBASE):** Request data from all devices to create a model as a function of T_e, N_e, V_p and M_p. Inter-machine comparison comparison with NGS scaling model. Additional factor(s) needed for stellarators? Basic comparison but can act as a seed!

L. R. Baylor, *et al.*, Nucl. Fusion **47** (2007) 443

$$\text{P. Depth} = C\, T_e(\text{keV})^{-5/9}\, N_e(10^{20}\ \text{m}^{-3})^{-1/9}\, m_p(10^{20}\ \text{atoms})^{5/27}\, V_p(\text{m/s})^{1/3} \quad (C = 0.079)$$

2) **HPI2 code:** Currently implemented for W7-X and LHD. Can benchmark W7-X version on TJ-II (2017). Can it be adapted for Heliotron J?
3) **Influence of fast electrons on ablation**: Proposal for next campaign on W7-X (open to external collaborators). Can attempt to generate fast electron in TJ-II ECRH plasmas. LHD sees fast ion ablation.
4) **19th LHD Experimental Campaign:** Joint research proposal to study strongly ECRH plasmas with suitable N_e profile (→ hollow) to determine if such hollow profiles can be mitigated with single injections or a series of injections, to what degrees slow diffusive particle transport and fast transport mechanisms are important.
5) **Intermachine comparison studies:** Similar sizes and parameters, (Heliotron & TJ-II) and (LHD & W7-X). Exchange of ideas for such studies between machines: Broadcast calls for proposals with due dates (TJ-II spring campaign is 26 January: send to kieran.mccarthy@ciemat.es)
6) **Transport of Deposited Material:** Evolution of density profile after deposition: Transport studies by JL Velasco.